

US PATENT APPLICATION.

**APPARATUS AND METHOD FOR IMPROVING THE QUALITY OF VIDEO
COMMUNICATION OVER A PACKET-BASED NETWORK**

THE INVENTORS

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BACKGROUND

Field of the Invention

The field of the invention is generally video communication and more specifically improved video communication quality over a packet-based network such as an Ethernet or Internet Protocol (IP) using H.323 protocol or similar standard.

Background Art

Conventionally, a packet-based network such as an Ethernet or IP does not offer an end-to-end connection with a guarantee that all packets will reach their destination. Therefore communication over a packet-based network using different technologies is necessary to overcome packet loss. For example, communication that is not performed in real time, such as e-mail, uses protocols such as Transmission Control Protocol (TCP), which is a handshake protocol that verifies the arrival of all packets. If a packet is not received, a request is made for a retransmission of the lost packet. Alternatively, other protocols, such as User Datagram Protocol (UDP)/IP,

typically send a notification about the problem of the packet loss and then handle the lost packet separately.

Video communications are performed in real time. However, any delay between endpoints (a physical location or apparatus that can generate and/or terminate information streams) reduces the quality of the communication performed in real time. Furthermore, a handshake protocol such as TCP/IP increases the delay, which is the time interval between the action of one side and the response of the other side. The increased delay damages the flow of a conversation. Consequently, TCP/IP is a difficult protocol to use for real time communications.

Therefore, video communications use UDP/IP with H.323, Session Initiation Protocol (SIP), or similar standards instead of using TCP/IP. UDP/IP is used primarily for broadcasting video streams over a network and it is a connectionless protocol, which runs on top of IP networks. Unlike TCP/IP, UDP/IP has very few error recovery services. Instead UDP/IP sends and receives datagrams over an IP network directly. Since UDP/IP does not have a feedback mechanism the packets that do not reach their destination will be lost. The percentage of packets lost during transmission is typically up to about 10%.

Conventional video communications use compression standards such as H.261, H.263 and Moving Pictures Experts Group (MPEG). These video compression standards typically have two types of frames: the “Intra” frame, which is a non-referential image, and the “Non intra” frame, which is a referential frame, similar to but not limited to frames such as Inter frame (P frame), B frame, and PB frame. Video compression standards use the difference between the current “Non Intra” frame and a previous frame for compression, regardless whether the previous frame was an Intra or “Non Intra” frame.

A video packet includes video parts, which may be a whole frame or part of a frame. Each frame may include one or more parts, where a part of a frame may include, for example, a few Groups Of Blocks (GOB), part of a GOB, Slice, part of a Slice or a few Macro Blocks (MBs). More information about said GOBs, Slices and MBs can be found in standards H.261, H.263, MPEG, etc.

Since video compression (i.e., encoding/decoding) is based on referential information, “Non Intra” frames, the loss of a packet may damage video quality for all later frames until a new Intra frame arrives. The loss of the packet may also cause loss of video synchronization. Typically, a video decoder of an endpoint handles lost packets by requesting transmission of an Intra frame so that the referential information of the Intra frame can be used to correct the synchronization and be the basis for calculating the referential frames that follow. This request for transmission can be performed by using a Video Update Picture Indication (VUPI) request.

A Multipoint Control Unit (MCU) is a node on a network, which provides the capability for two or more terminals to participate in a multimedia communication session. Therefore, the MCU may transfer a received data stream with missing packets, to multiple participants’ endpoints. Thus the use of MCUs may create a bigger problem than just a lost packet in an endpoint-to-endpoint direct connection, because the lost packet will be missing to multiple endpoints rather than just one endpoint. . There are few known ways by which an MCU handles missing packets; none of which replace the missing packets. For example, the MCU may send video source packets while ignoring the missing packets, and let the endpoints make a VUPI request. In a videoconference with more than two endpoints, several participants may simultaneously receive communications from one source, such as a conference speaker. If a packet is lost during transmission from the video source (the conference

speaker) to the MCU, each of the participants would request a VUPI from the MCU. However, the numerous VUPI requests and the INTRA frames that the follow VUPI requests could overwhelm the network, especially if there is a high packet loss rate. Further, during Internet communications each participant may experience packet loss at a different time, and will therefore request a VUPI at different times, thereby overwhelming the network with sporadic transmissions of Intra frames. Since Intra frames are approximately 10 times “bigger” than “non Intra” frames, transmission of Intra frames may cause frame rate derogation and reduces the video quality of the conference.

Therefore, there is a need for a system and method for improving video communications quality over a packet-based network.

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SUMMARY OF THE INVENTION

2 The present invention provides a novel method and apparatus for repairing
3 video stream errors such as missing packets of an incoming compressed video stream.
4 The system identifies a missing part or unit of a video stream (e.g., a lost packet) by
5 tracking a sequence number associated with each packet. An analysis is then
6 performed to determine which sub-units (e.g. GOBs, Slices, and/or MBs) are absent
7 from the video stream, and to create one or more substitute video stream parts (i.e.
8 repair packets) to compensate for absent sub-units. In an exemplary embodiment the
9 repair packets include the minimum required video bits to keep the stream or flow of
10 the video stream synchronized. This minimum bit requirement means that none of the
11 MacroBlocks' (MBs') video data is placed or reconstructed in the packet. Instead, a
12 decoder treats a repaired video stream part, such as a GOB, as an uncoded part that
13 represents the same information as in the previous frame. The repaired information is
14 then transferred to its destination and replaces the original information.

15 Additionally, the MCU may ask for an “update request” from the video
16 source, which may include a VUPI request. When compression standard allows, only
17 a part of a picture that includes the missing sub-units (such as MBs) is requested. An
18 example of a compression standard that allows for the request of a partial picture is
19 H.263.

20 Replacement of the missing parts provides for continuity of the video stream
21 at a receiver site. This continuity enables smooth parsing, without synchronization
22 losses and prevents re-synchronization process by the video “decoders.” The decoder,
23 among other places, may be located inside the MCU, or outside of the MCU at the
24 participant’s endpoint.

- 1 Alternatively, if the missing part belongs to a nonreferential image (e.g., an
- 2 Intra frame), then the video stream is not corrected. Instead a new nonreferential
- 3 image (such as Intra frame) is requested.

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BRIEF DESCRIPTION OF THE DRAWINGS

2 The invention will be more readily understood from reading the following
3 specification and by reference to the accompany drawings showing an example of the
4 invention.

5 FIG. 1 is a block diagram of a prior art network interface unit;

6 FIG. 2 is a block diagram of an exemplary embodiment of the present
7 invention; and

8 FIG. 3 is a flow diagram of the steps of an exemplary embodiment of the
9 present invention.

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DETAIL DESCRIPTION OF THE INVENTION

2 Fig. 1 is a block diagram of a prior art network interface unit 100. As shown,
3 a Local Area Network (LAN) controller 110 grabs required multimedia packets from
4 a LAN 101 via a buffer 111. Preferably, the LAN controller 110 then sorts the
5 multimedia packets into two types of streams: control streams 160 and media streams
6 135. The control stream 160 is transferred via buffers 161 to a backplane 170.

7 The media streams 135 are transferred to a Real Time Transfer Protocol (RTP)
8 unit 120, a packetizing/depacketizing unit that sorts the streams into Audio streams
9 150, Video streams 140 and Data streams 130 and transfers them via buffers 141, 151
10 and 131, respectively, to the backplane 170. More specifically, video streams 140 are
11 transferred through buffer 141 to the backplane 170 without repairing the missing
12 packets, while audio streams 150 are transferred via buffer 151.

13 Conversely, FIG. 2 is a block diagram illustrating an exemplary embodiment
14 of a network interface unit 200 according to the present invention. Preferably, the
15 network interface logical unit 200 includes a LAN controller 110, RTP unit 120,
16 Video streams 140, Missing Packets Repair logical Unit (MPRU) 210, Packet
17 Analyzer logical unit (PA) 220, memory 230, GOB history memory 240, GOB
18 Analyzer logical unit (GA) 250, Packet Repair logical unit (PR) 260, and Temporary
19 Packets Memory (TPM) 265.

20 It should be noted that the term “GOB” represents a “Slice” for situations
21 where slices are used instead of GOBs. In such a case, the GOB ID Number is
22 replaced by the Slice ID, which is the MBA field in the Slice header. The MBA
23 indicates the first MB in the Slice.

1 The network interface logical unit 200 is similar to network interface unit 100
2 (FIG. 1) in that they both include a LAN controller 110 and RTP unit 120. However,
3 in contrast to the prior art device of network interface 100, the FIG. 2 system also
4 includes a Missing Packets Repair logical Unit (MPRU) 210.

5 Operationally, video streams 140 from the RTP 120 are transferred to the
6 MPRU 210. Inside the MPRU 210 the video stream 140 is distributed to three logical
7 units: PA 220, GA 250, and PR 260. The PA 220 reads a current packet sequence
8 number of a received packet, compares the current sequence number to the expected
9 sequence number, and in case of mismatch sends indications of packet loss to the
10 LAN controller 110, GA 250, and PR 260. The expected sequence number is based
11 on the history of the received packets stored in its memory 230.

12 The GA 250 analyzes which GOBs/Slices are associated with each received
13 packet and stores this information in the GOB history memory 240. The analyzing
14 can be done by parsing the video stream of a packet and/or by grabbing the
15 information regarding the GOB/Slice ID from the RTP header. This information
16 about the GOB/Slice header in the RTP Header does not always exist and is based on
17 the RFC.

18 When the GA 250 receives an indication that there are missing packets prior to
19 the current packet, GA 250 uses the last stored information in the memory 240 and the
20 first GOB/Slice ID Number that was found in the current packet to analyze which
21 GOBs/MBs are missing. The GA 250 then sends this information to the PR 260,
22 which in turn receives the incoming video stream 140 of packets and stores them in
23 the Temporary Packet Memory (TPM) 265. Thus, the TPM 265 receives both
24 indications about a missing packet from the PA 220 and the identification numbers of
25 the corresponding missing GOB/MBs from the GA 250. If there are no missing

1 packets, the PR 260 reads the last stored packet from the TPM 265 and sends the
2 stored packet, as is, via buffer 271 to the backplane 170. When the PR 260 receives
3 the indications from the PA 220 and from GA 250, the PR 260 creates repaired
4 packets and sends the corrected stream, including the repaired packets with the stored
5 packets from the TPM 265 via buffer 271 to the backplane 170. The determination of
6 which GOBs/MBs are missing is based on the compression standard as explained
7 below by example.

8 Fig. 3 is a flow diagram illustrating steps of an exemplary method for
9 repairing missing packets according to the present invention. Initially, the MPRU
10 210 (FIG. 2) receives a next packet in step 300. The PA 220 (FIG. 2) then reads
11 the sequence number of the packet in step 310 and compares the sequence number
12 of the packet to the sequence number of the previous packet stored in the memory
13 230 (FIG. 2). Subsequently, the PA 220 (FIG. 2) checks if the packet is
14 consecutive in decision box 320 based on the comparison of the sequence
15 numbers. If the packets are consecutive, the PA 220 stores the current packet's
16 sequence number in the memory 230 and returns to step 300 to receive a new
17 packet. However, if the packets are not consecutive, meaning that one or more
18 packets have been lost, then PA 220 checks if the missing packet belongs to an
19 Intra frame or "Non Intra" frame in step 340.

20 One way of keeping track of the type of frame is to sample the indication
21 of frame type. For example, the PA 220 may check the frame type by reading a
22 "frame's header," GOB "0" of the last packet. In H.263, the frame header is part
23 of a header of GOB "0" while in H.261 the frame header is identified by GOB ID
24 Number "0".

1 If the missing packet is part of Intra frame 340, no packet repair is necessary
2 and a VUPI request is performed in step 380 and the process returns to step 300 to
3 receive the next packet. If the packet contains part of a “Non Intra” frame the PA 220
4 sends a missing packets acknowledgement to the GA 250 (FIG. 2) and the PR 260
5 (FIG. 2). The GA 250 in step 350 uses the information stored in the memory 240
6 (FIG. 2) to get the last GOB ID Number that arrived before the missing packets. For
7 example, if the last GOB before the missing packet is GOB (j), then the GA 250 finds
8 the first GOB in the current packet in step 360, e.g., GOB (k). Based on these two
9 GOB ID Numbers (i.e., (j) and (k)), the compression standard, and the source format
10 (e.g., Common Intermediate Format (CIF), 4 CIF, or Quarter CIF (QCIF)), the GA
11 250 determines in step 365 which are the missing GOBs.

12 In the case that the compression stream is using Slices instead of GOBs, the
13 GA 250 analyzes and stores the last Slice ID, which is the MBA field in the Slice
14 header of the last received packet. Then the GA finds the Slice ID of the first Slice.
15 By using this two MBAs and the width of the Slice the GA 250 analyzes which MBs
16 are the missing.

17 The following are a few examples of the analysis, for video algorithms H.261
18 and H.263 and two sources formats CIF and QCIF. The numbers in the following
19 table specify the sequence of GOB ID Numbers used in those cases.

20

	QCIF	CIF
H.261	0,1,3,5	0,1,2...12
H.263	0,1,2...8	0,1...16,17

21

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1 The GA 250 recognizes the missing GOBs by finding the GOBs missing in the
2 sequence. Thus:

3 a. For H.261 and QCIF, if $j=0$ and $k=5$, then the repaired packet would
4 include GOBs 1 and 3.

5 b. For H.261 and CIF, if $j=4$ and $k=0$, then the repaired packet would
6 include GOBs 5,6,7...12.

7 c. For H.263 and QCIF, if $j=6$ and $k=2$, there are 2 packets that need to be
8 repaired. The first packet includes GOBs 7 and 8, and the second
9 packet includes GOBs 0 and 1. A packet is not allowed to include
10 GOBs from different frames.

11 d. For H.263 and CIF, if $j= 17$ and $k=6$, the repair packet includes GOBs
12 0, 1, 2...5.

13 e. For H.261 and CIF, if $j=4$ and $k=5$ no repaired packet is needed.

14 If a GOB ID Number is not found in the current packet, no analysis can be
15 performed and the GA 250 drops the current packet. Subsequently, the process
16 returns to step 300 and waits for the next packet.

17 The GA 250 transfers the results of its analysis (i.e., the missing GOB ID
18 Number) to logical unit PR 260 (FIG. 2), which in turn prepares the necessary
19 repaired packet or packets in step 370.

20 The packet repair is done based on the compression standard, and the
21 source format, each packet includes the necessary bits plus some extra bits or
22 “stuffing” that keep the continuity of the stream as required by the protocol in use.
23 For example H.261 requires just the GOB headers with no byte alignment, while
24 H.263 requires 1 bit for each non-coded Macro Block (MB). Since H.263 CIF
25 GOB includes 22 MBs, 22 bits of ‘1’ are needed. H.263 QCIF GOB includes only

1 11 MBs, so in this case 11 bits of ‘1’ are needed. These bits are added to the GOB
2 header. Further, the H.263 frame should be byte aligned, which is guaranteed by
3 the H.263 stuffing.

4 The PR 260 sends the repaired packet or packets with the current packet as
5 a corrected video stream to the backplane in step 390, and sends an update request
6 to the video source in step 380. Conversely, if the PR 260 does not get a missing
7 packet indication from the PA 220, the PR 260 sends the current packet, as is, to
8 buffer 271. The update request might be a VUPI request, however it is not always
9 necessary. Alternatively, in H.263 a message “VideoNotDecodedMb” may be
10 used and only the missing GOBs/MBs may be updated.

11 The MPRU 210 can be implemented by software (e.g., an additional software
12 package loaded to an existing processor, such as RTP processor 120). Alternatively,
13 the MPRU 210 may be an additional processor including programs or special
14 hardware for all three units, the PA 220, the GA 250 and the PR 260, or three separate
15 processors, one per unit or any combination of one to three processors and/or
16 hardware units. Memories 230, 240 and TPM 265 (FIG. 2) can be implemented by
17 any one of, or any combination of, SRAM, DRAM, SDRAM, internal and/or external
18 memory.

19 Although the above exemplary embodiments are given in terms of streams,
20 packets, GOBs, and Slices, the invention can be applied to video streams that are
21 divided into other units, parts, and/or sub-units. Similarly, the missing packet repair
22 unit, MPRU 210, is just an example of a missing part repair unit.

23 As can be understood from the above description, the present system improves
24 traffic over a network by replacing missing GOBs/Slices, and thereby enhances the
25 continuity of data streams at a receiver side. The continuity of the data stream enables

1 smooth parsing (without synchronization losses and re-synchronization process) by
2 video “decoders” and improves the quality of video communication. In the
3 description and claims of the present application, each of the verbs, “comprise”
4 “include” and “have”, and conjugates thereof, are used to indicate that the object or
5 objects of the verb are not necessarily a complete listing of members, components,
6 elements or parts of the subject or subjects of the verb.

7 While the invention has been described with reference to specific
8 embodiments, it will be understood by those skilled in the art that various changes
9 may be made and equivalents may be substituted for elements thereof without
10 departing from the true spirit and scope of the invention. In addition, modifications
11 may be made without departing from the essential teachings of the invention.